Hydrocarbon Explosion Myths

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Based on information readily available in the public domain

Photos courtesy of:
Primis.phmsa.dot.gov/rd/mtgs/022806/17_RemarksZarea.pdf
www.ntsb.gov/Dockets/Pipeline/DCA08MP001/default.htm
www.buncefieldinvestigation.gov.uk/index.htm

Dispelling Explosion Myths

- All forms of hydrocarbons can explode ("detonate") in many environments under certain conditions
  - e.g.
    - Hydrogen
    - Natural Gas
    - Crude Oil, Light Products/Gasoline/Jet Fuel/Diesel/Gas Oil/Fuel Oil
    - LNG
    - Carbon based solid dust forms such as grain dust, coal dust
- Today's discussion won't address "other chemical" forms of hydrocarbon detonation initiation
  - Focus on physical initiators

Hydrocarbon Handlers

- Too often seeing “can’t explode” statements cited out of context in dismissive, incomplete, or gamed studies
- False claims of “can’t detonate in the open” taking on an urban mythology, especially in risk management
  - Represents lack of real experience, reflective of poor science, and reckless/speculative risk management approaches
  - Clear signal of a failure to grasp other physical factors that can cause hydrocarbon explosions, especially in the open
  - Results in failure to exercise proper siting/safety/precautions
- Many circumstances need to consider explosion as well as thermal risks
  - Explosion is a lower probability very high consequence event

Why the Explosion Miscue?

- Unconfined Vapor Cloud Explosions (UVCE)
  - Not well understood by many so called “experts”
    - Most First Responders not properly trained
    - Models capture these concepts poorly
  - Misunderstanding of hydrocarbon properties, explosion characteristics, and release dynamics
    - Flash point and explosion not really related in many release scenarios
    - Confusion on activation energy, explosion range, and how these properties vary
      - All hydrocarbon releases transition through an explosive range somewhere
      - Mixtures can really increase the likelihood of explosion
- In explosion impact zone
  - Survivability of people and structures decreases markedly from overpressure
  - Fortunately forces dissipate quickly with distance
- Thermal radiation usually much larger zone then explosion
- To be fair – many releases do not detonate
  - Four factors required to come together for hydrocarbon explosion

Additional Confusion Caused by

- Failure to grasp difference between deflagration vs. detonation and how a release can transition
- Misguided belief one needs backpressure from "congestion" to have explosion
  - Recommend avoiding the "cute" congestion qualifiers
- Very poor understanding of certain hydrocarbon release dynamics and properties that physically boost likelihood of explosion
  - Many decision makers or management teams failing or missing prudent prevention processes leading to highly speculative "uniformed" decisions
    - Illusions of safety can actually drive systems to failure

Today's Focus on UVCE

- Don't need to discuss in detail special UVCE sub cases of BLEVEs (Boiling Liquid, Expanding Vapor Explosions)
  - Liquid released from containment that is stored under greater than atmospheric pressure at a temperature above its atmospheric boiling point
  - BLEVE overpressure and detonation phenomena well understood – even in open areas
- Concentrate today on liquids that can aerosol or gas releases that can generate "appropriate" UVCE without BLEVE.

Hydrocarbon Releases and Ignition

- Deflagration - slow combustion front velocity, < sonic velocity
  - Many conventional hydrocarbon fires
  - Pooled liquid events
  - Flash fires
- Fireballs ↑↓ (can easily transition to explosion)
- Detonation (Explosion) - flame front boost to ≥ sonic velocity, must estimate overpressures
  - Overpressure/non-survivability effects (even in open) well known
  - Hydrocarbon high rate release dynamics at risk to explosion
  - Watch out for high mass rate aerosoling of liquids

Natural Gas Pipeline Detonation

Ghislenghien, Belgium - 7/30/2004

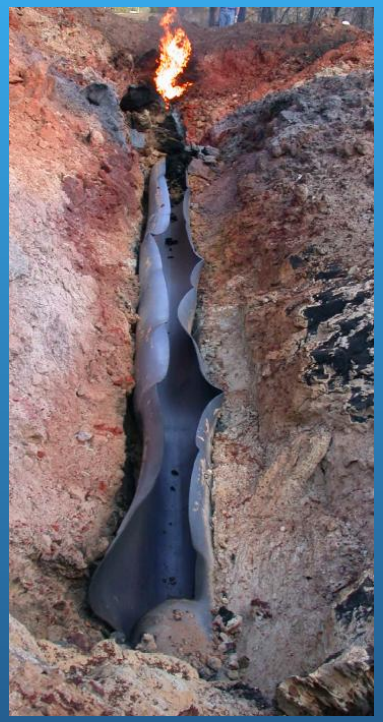
40-inch 1160 psi pipeline. Rare leak to rupture transition failure with rupture explosion in the open

Seismic estimated explosion at ~ 40 tons high explosive equivalent

28 Dead (many first responders killed, thrown by blast), 150+ injured

Dixie Liquid Pipeline

Carmichael, MS USA – 11/1/2007



12-inch propane pipeline exhibiting classic ERW seam rupture*

~70 acres burned, 2 dead

While propane can BLEVE, this release was not a BLEVE driven event

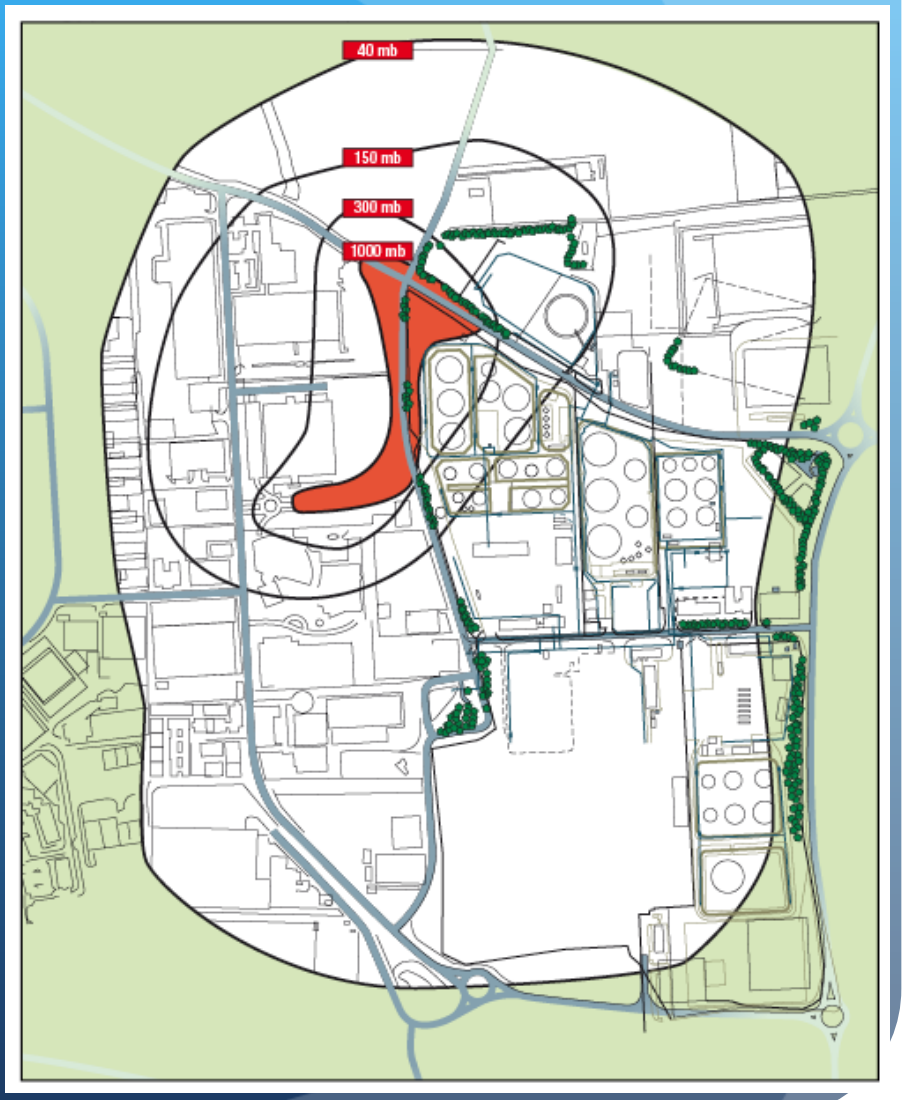
Rupture Site

Victims, destroyed structures & vehicles ~ 450 to 550 ft from rupture

*Initiating cause of failure not yet made public

Offsite Tank Farm Release

Buncefield, England – 12/11/2005



Vapor cloud explosion from gasoline loss of containment from tank farm - Majority of vapor cloud not confined

Seismic estimated blast 2 – 10 tons high explosive equivalent

Bottom Line

- Need to consider explosion as well as thermal risk zone limits in many hydrocarbon facility risk management studies
- Watch for incomplete or clearly biased studies/reports
  - Tainted, limited, or gamed risk management ignoring explosion
- Be sure risk management approaches are complete and prudent
  - Failures are properly addressed – not imprudently dismissed
  - Some facilities more at risk of explosion ("the exotics")
  - Some transmission pipelines
  - LNG ships (aka Rapid Phase Transition, or RPT)
  - Tank farms that are at risk of "boilover"
  - Poorly sited/designed/operated hydrocarbon facilities
- Operator needs to maintain facility "proper control" through lifecycle
  - In many countries speculative risk can have unlimited liabilities